

"The Colour-physiology of Higher Crustacea." By FREDERICK KEEBLE, M.A., Reading College, Reading, and F. W. GAMBLE, D.Sc., Owens College, Manchester. Communicated by Professor S. J. HICKSON, F.R.S. Received July 16, 1902.

(Abstract.)

The following statement is a condensed summary of the results of a research into the form and physiology of the pigment-bearing organs (chromatophores) of certain Schizopod and Decapod Crustacea with especial reference to the effect of light on these organs and on these animals. The evidence for the statement will appear in a full and illustrated form in the "Philosophical Transactions." The Grant Committee of the Royal Society allotted £25 for this research.

A. The Influence of Light.

1. Under the influence of light the secretory activity of certain organs is modified: an acid substance appears periodically in the "liver" and muscle: the appearance and disappearance of acid substance in liver and muscle coincides broadly with nocturnal and diurnal colour-change.

2. In the progressive movements and orientations of the whole animal called forth by light, background is the most important factor: more powerful than change of light-intensity. By change of background, black to white, the direction of a light-induced movement may be reversed.

3. The response of the chromatophore-pigments to light is two-fold: direct; and indirect, through the mediation of the eye. The indirect response alone leads to an enduring redistribution of pigment.

4. The ultimate effect of monochromatic light on pigment-movement is the same as that of white light. As with the latter, so with monochromatic light, background—white (scattering), black (absorbing), mirror (reflecting)—determines the nature and extent of the pigment-movements. In describing an effect of light, that light must be considered in combination with its background. Neglect to do this must lead to erroneous conclusions.

5. "Reaction to background" is traceable to the eye, and is probably a consequence of an asymmetrical distribution of retinal pigment brought about not by changes in the amount of light falling on the eye, so much as by changes in the way in which light falls on the eye.

B. The Rôle of Pigments.

6. The phenomena presented by the pigments are not exhaustively explained by any "protective" hypothesis.

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The chromatophores are centres of metabolic activity, and from them a nocturnal translocation of a blue substance takes place. There is evidence that this blue substance is produced from, and at the expense of, the diurnal chromatophore-pigments. The blue substance passes from the chromatophore-centres, persists for a time in the body, and ultimately disappears.

C. *Morphology.*

7. The chromatophore-system of Mysidean Schizopods is built upon a common plan, of which the various genera and species present severally a constant modification. This system we call the primary chromatophore-system. To it the colour-pattern is due.

8. Decapod Crustacea possesses a primary and a secondary system of chromatophores. The primary system appears in the embryo, is completed in the "*Mysis*-stage," and persists throughout life, but takes no part in colour-pattern.

The secondary system arises in an early stage of development, increases in extent throughout life, and produces the colour-patterns of the adolescent and adult.

9. The chromatophores of the primary system are profusely branched, few in numbers, segmentally arranged and centralised; those of the secondary system are sparsely branched, numerous, irregularly arranged and decentralised.

D. *Histology.*

10. The chromatophores of Mysidæ are multicellular organs. Those of the neural group are developed from the epidermis. Losing their connection with the epidermis they acquire a close relation with the central nervous system. The distribution of the primary chromatophore-system follows that of the ganglionic parts of the nervous system.

11. The chromatophores of Decapods are plurinuclear connected structures: their distribution is not confined to the ganglionic parts of the nervous system.

E. *Taxonomy.*

12. The primary systems afford assistance in the determination of genera and species. By their aid, animals in early, as well as in late, stages of development may be diagnosed.

F. *Inheritance.*

13. The several adult colour-patterns of *Palæmon* and *Crangon* are constant, and develop directly. The evidence tends to prove that both secondary and primary chromatophore-systems are inherited.

14. The adult colour-pattern of *Hippolyte cranchii* is constant, but develops indirectly. The adolescent possesses a special colour-pattern developed in large measure in relation with the primary system of the zoea. Both persist though concealed by the independently developed adult pattern.

15. In *Hippolyte varians*, several adult colour-patterns occur. They develop indirectly. The primary system is the same in all.

In the adolescent, three distinct colour-patterns arise:—"barred," "liner," and "monochrome."

These may persist, becoming barred, liner, or monochrome adults.

Or either "barred" or "liner" may, by developing superficial or deep chromatophores, become a monochrome.

Or, by localised superficial developments either "barred" or "liner" may give rise to a "blotched" adult colour-form, under which the adolescent pattern is hidden.

The primary system is inherited: the adolescent colour-patterns are possibly inherited; but inheritance is immaterial since the final goal is reached by any adolescent road; that is, the adult colour-pattern of *Hippolyte varians*, is the result of environment.

"Observations on 'Flicker' in Binocular Vision." By C. S. SHERRINGTON, M.A., M.D., F.R.S. (Thompson-Yates Laboratory of Physiology, University College, Liverpool). Received July 30, 1902.

The connection between the physiological state and reactions of the two retinae right and left is close in many respects; this is true particularly and peculiarly for their areas that are conjugate in binocular vision, that is, which receive corresponding images of objects perceived in the binocular field. The observations at basis of the following communication attempt to obtain further information regarding the nature of the tie between these retinal so-called "identical spots." A practical aim was to measure by the "flicker" method of photometry any difference of physiological luminosity existent between binocular and unocular vision of a given illuminated object.

An object intermittently illuminated gives, if the frequency of intermission be sufficient, a perfectly steady sensation. The successive retino-cerebral reactions fuze into a continuous one as judged of by sensation. If the rapidity of intermission be less than the requisite, the sensation oscillates through lighter and darker phases. The transition from the oscillating to the steady sensation and *vice versa* is sufficiently abrupt to form a transition point capable of fairly definite